

3.2.3. WATER VAPOR AND OZONE PROFILES OVER THE TROPICAL PACIFIC DURING CEPEX

Introduction

The Central Equatorial Pacific Experiment (CEPEX) took place during March 1993. The broad objective of this experiment was to obtain the measurements necessary to establish the roles of cirrus radiative effects and surface evaporation in limiting maximum surface temperature in the equatorial Pacific. In addition to playing a key role in climate in the western and central Pacific region because of the strong convection, it is also the major area where material from the troposphere can be injected into the stratosphere. Because of the cold tropopause temperatures seen in this region during the boreal winter and spring, air passing through the tropopause is dried as it enters the stratosphere. Understanding of the mechanism for this drying is an active area of research and a major focus of this effort. In addition, the horizontal circulation induced by the convection (Walker circulation) was also investigated.

Measurements

Water vapor and ozone profiles were obtained from the research vessel *John Vickers* as it sailed northeast from Honiara, Guadalcanal (9.5°S, 160°E), to Nauru (0.3°S, 166.5°), then east to Christmas Island (2°N, 157.5°W). Soundings were made from Christmas Island (Kiritimati) for a week (March 20-26) at the end of the ship cruise (March 7-18). During the experiment there were at least 13 partially successful water vapor soundings and 26 ozone soundings. On 12 of the flights, the ozone and water vapor were measured simultaneously. The water vapor profiles were obtained using a balloonborne frost-point hygrometer. For many years such instruments were used to make stratospheric water vapor measurements in Boulder. The uncertainty in the mixing ratio is about $\pm 10\%$. Ozone was measured with a digital version of the ECC ozone sensor that also has a long history of ozone profile measurements. The estimated uncertainty in the ozone partial pressure is $\pm 5\%$ in the stratosphere and $\pm 7\text{--}10\%$ in the troposphere.

Both the water vapor and ozone profiles could be classified into three groups with rather distinct features based on the longitude (and time) of the observations. In the most westerly group of soundings (west of 174°W) done between March 7-13, there was a very low minimum water vapor mixing ratio (<1.5 ppmv) that corresponded in altitude to the local tropopause (**Figure 3.25a**). Ozone was very low (<30 ppbv) throughout the troposphere with a sharp increase in the mixing ratio at the tropopause. Although the only successful water vapor sounding when active convection was nearby was on the first day, the satellite imagery showed strong convection in this region throughout the period of observations. The

very low water vapor mixing ratios at the tropopause indicate air is being dried as it passes through this cold trap. The observations of water vapor at the tropopause never showed saturation, but minimum temperature measured during the four-times daily radiosonde ascents were very close to the measured frost-point temperature. Minimum radiosonde tropopause temperatures in this region usually occurred at night or early morning, while the water vapor soundings were done later in the morning. It also may be that the saturation at the tropopause occurs only during the deep convective events when no successful balloon ascents were made.

In the second group of soundings that were done between 173°W and Christmas Island close to the equator, mixing ratios increase a bit at the tropopause but are still low (1-2 ppmv). Above the tropopause amounts are higher by about 1 ppmv. The shape of the profiles in these two groups is also generally the same. In this region convection was not intense and the tropopause was further from saturation even though frost-point temperatures were warmer. The main characteristics of the upper troposphere and stratosphere in this region appear to reflect the processes taking place further to the west.

For the final group of soundings done at Christmas Island at the tropopause (**Figure 3.25b**), the minimum water vapor mixing ratio was between 2.5 and 3.5 ppmv. There is an absence of a sharp step in ozone at the tropopause, and ozone values were much higher in the upper troposphere. Convection, although present over Christmas Island, was not deep and hence neither the ozone nor water vapor profiles show characteristics seen in the more convective region.

Discussion and Conclusion

The water vapor and ozone profiles obtained during CEPEX show that deep convection in the western Pacific dries air passing through the tropopause to very low values (~ 1 ppmv), which is the primary factor in establishing the dryness of the stratosphere. This drying takes place over a broad region as evidenced by the large horizontal extent over which dehydration was observed. The single, sharp minimum in temperature at the tropopause supports a mechanism for dehydration associated with deep convection in tropical disturbances [Danielsen, 1993].

The changes in the stratospheric water vapor profiles seen at Christmas Island not only represent conditions further to the east out of the deep convective region but they also reflect a change in flow pattern in the lower stratosphere. The relatively high ozone values seen in the upper troposphere indicate transport from the stratosphere into the troposphere consistent with downward motion in the eastern branch of the Walker circulation.

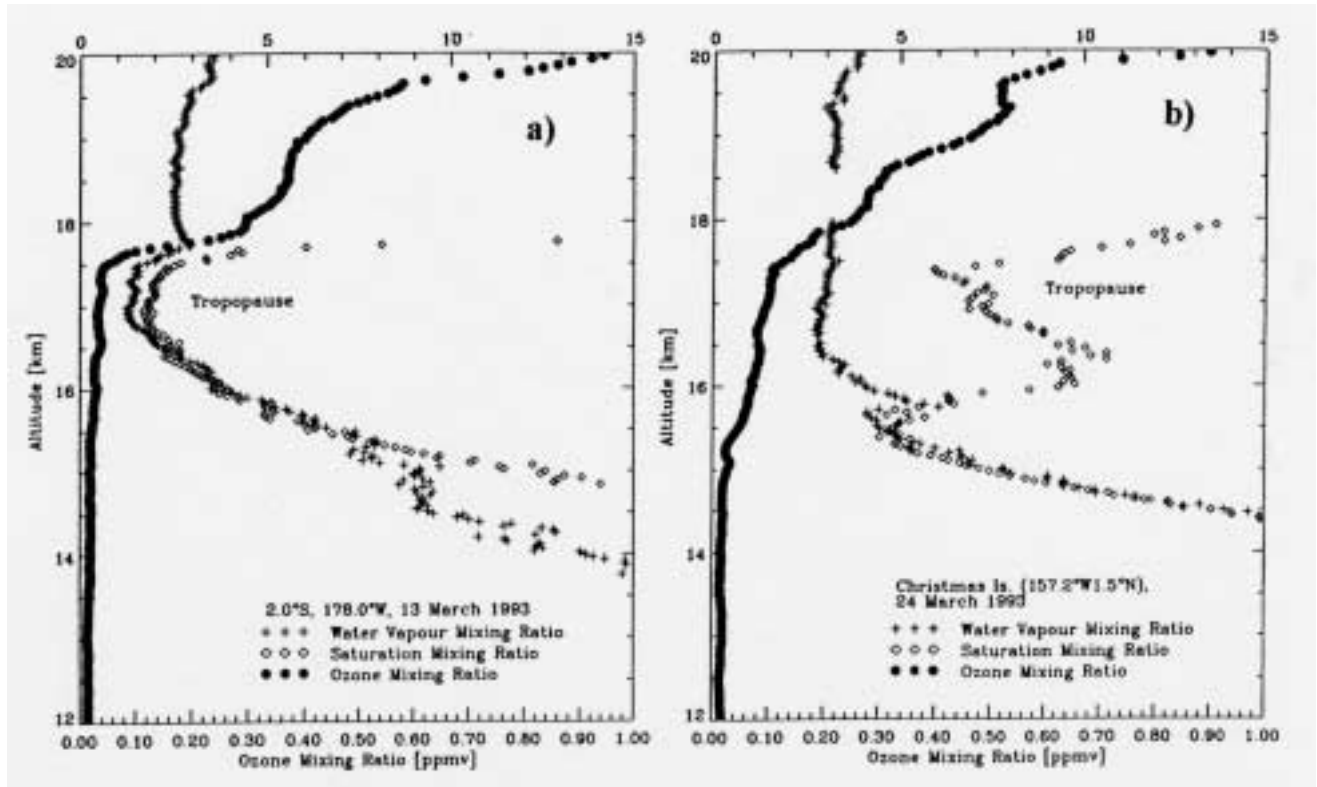


Fig. 3.25. Water vapor and ozone mixing ratio profiles from the upper troposphere and lower stratosphere during CEPEX. In (a) the profiles were obtained near the equator at the dateline and show the affects of deep convection. In (b) the profiles done on Christmas Island do not show convection penetrating to such high altitudes.